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Behavior of Red Clay and Fly Ash Bricks under Uniaxial Compression

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Abstract: *Masonry is one of the oldest material used in the structures, but its mechanical properties has not yet been fully investigated. This paper deals with behavior of masonry materials under uniaxial compression loading. Red clay bricks and Fly ash bricks PRISM are casted and tested. In this paper, the evaluation of the individual properties of the Bricks and Mortar is carried out. Individual properties like Brick Compressive Strength, Water Absorption is evaluated as per IS 3495-1992[5] . 5 Layered, 6-Layered and 7- Layered PRISM are casted and tested under the uniaxial compressive loading for Red Clay Bricks and Fly Ash Bricks. The mechanical properties like basic compressive stress and Modulus of Elasticity are determined as per IS 1905-1987[7]. The results shows that the basic compressive strength and modulus of elasticity of red clay bricks is much more as compared with Fly Ash Bricks.*

Key Words: **Red clay bricks, Fly Ash Bricks, PRISMS, Stress Strain.**

1. INTRODUCTION

Masonry is one of the oldest material used in the structures, but its mechanical properties has not yet been fully investigated. Recently, there has been some systematic guidelines and practices has been initiated for the evaluation of the properties of the masonry materials. Commonly masonry materials available are Red clay Bricks, Fly Ash Bricks. Because of having higher density for Clay Bricks of about 19000 Kg/m^3, Fly Ash bricks has recently gained the market as it has a lower density of about 600 kg/m^3.
Present study deals with the testing of the constitutive materials as well as casting and testing of 5,6 and 7-Layered Red Clay Brick and Fly Ash Bricks PRISMS. The dimensions of the PRISM specimens are selected in such a way that the height to thickness ratio is in the range as specified in IS 1905-1987[7]. The PRISM are tested under uniaxial compression loading in the UTM machine having capacity of 1000 kN. The mechanical properties like basic compressive strength and Modulus of Elasticity for both the type of materials has been obtained experimentally as per IS 1905-1987[7]. Then these parameters are compared within themselves.

2. LITERATURE REVIEW

Many studies have been done on the evaluation of the mechanical properties of the infill materials as well as on the behavior of the RC infill panels under lateral load. Sarangapani et al.[1] have studied Mortar and Compressive Strength of masonry. It has been showed that masonry compressive strength is not affected by mortar bond strength significantly. For poor bond strength, masonry prism leads to failure through bond separation of one or more joints. AlShebani and Sinha[2] studied deformation characteristics of a sand plast (a form of calcium silicate) brick masonry model subjected to uniaxial cyclic loading in both perpendicular and parallel direction of the bed joint. Failure in compression occurred by splitting in bed joints for loads parallel to the bed joint, whereas for load normal to the bed joint, failure was characterized by a combined failure in the brick units and/or head joint, often accompanied by through-splitting in the midsection of panel. Hamid and Chukwunenye[3] showed that h/t ratio has a significant influence on the behavior of masonry prisms. Study suggests that practice of concrete masonry prisms with h/t = 2.0 and one bed joint as standard prism should be discontinued, and prisms with number of bed joints greater than or equal to two should be used to determine the compressive strength of concrete masonry prisms. Naraine and Sinha[4] studied the stress-strain characteristics of brick masonry prisms under cyclic compressive loading. Specimens loaded perpendicular to the bed joint, the failure was characterized by splitting of the bricks in a plane parallel to the plane of the panel while specimens loaded parallel to the bed joint, the failure occurred by splitting in the vertical bed joints accompanied by some vertical cracks in the bricks.

3. TEST ON CONSTITUTIVE MATERIALS

Compression and Water Absorption tests were carried out as per the provisions given in IS 3495-1992[5]. Total 5 specimens each for Red Clay Bricks and Fly Ash Bricks were tested. Total 36 cubes for mortars for 1:4 cement: sand ratio having water/cement ratio of 0.85 were tested under compression [6]. Results for the same is tabulated in Table -1

Table -1: Test on Constitutive Materials

Material	Compression Test (N/mm^2)	Water Absorption
Red Clay Bricks	7.60	17.56
Fly Ash Bricks	4.10	32.73
Mortar	6.07	-
Test on bricks were carried for 5 number of specimen for each material		

4. TEST ON RED CLAY BRICK PRISMS

Three specimens for 5, 6 and 7- Layered each were casted as per the provisions specified in IS 1905. For simplifying the specimens, the labels are given to each specimens like 5 Layered Red Brick Specimen No.1 is labelled as 5RBP-1 and likewise. Total 9 specimens were casted and tested under compression on the UTM having capacity of 1000 kN. The dimensions of all Red Clay Bricks specimens is mentioned in Table-2. The PRISMS specimens are shown in Figure-1.

Table-2: Details of Red Clay Brick PRISMS

Sr No.	Details	Dimensions (mm) H × W × B	Label
1	5 Layered Red Brick Specimen-1	411.22 × 218.33 × 222.33	5RBP-1
2	5 Layered Red Brick Specimen-2	415.55 × 223.17 × 216.67	5RBP-2
3	5 Layered Red Brick Specimen-3	416.11 × 223.33 × 223.33	5RBP-3
4	6 Layered Red Brick Specimen-1	521.11 × 227.33 × 225.00	6RBP-1
5	6 Layered Red Brick Specimen-2	510.55 × 222.50 × 220.00	6RBP-2
6	6 Layered Red Brick Specimen-3	494.44 × 228.33 × 224.16	6RBP-3
7	7 Layered Red Brick Specimen-1	573.33 × 228.16 × 225.83	7RBP-1
8	7 Layered Red Brick Specimen-2	616.67 × 230.83 × 227.50	7RBP-2
9	7 Layered Red Brick Specimen-3	571.67 × 225.83 × 225.83	7RBP-3

Figure-1: Red Clay Brick PRISMS

Figure-2: Test Set up

These specimens are tested under compression load in the Universal Testing Machine of capacity 1000 kN. The specimen is loaded till the failure of the specimen. The test set up of the Red Clay Brick PRISM is shown in Figure-2. The strain is measured with the help of the dial gauge of 50 mm.

The stress- Strain curve for all red brick clay specimen is shown in Figure-3.

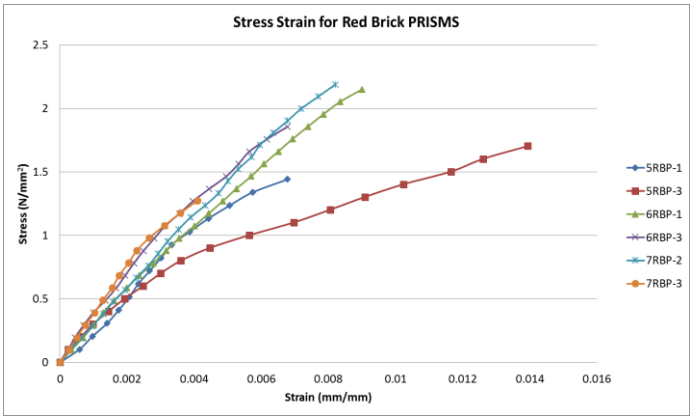

Figure -3: Stress Strain Curve for Red Brick PRISMS

The failure of specimens for Red Clay PRISMS is shown in Figure-4. Most of the failure is very much in line with the literature available. Cracks initiates from the failure of mortar and gradually passes through the bricks. Vertical Splitting and diagonal cracks were also observed. Corner crushing and bond failure were of predominant nature.

Splitting Failure of 6-Layer Red Brick Prism

Bond Failure of 7-Layer Red Brick Prism

Spalling of Brick of 7-Layer Red Brick Prism

Corner Crushing of Brick of 5-Layer Red Brick Prism

Figure -4: Failure of Red Clay Brick PRISMS

5. TEST ON FLY ASH PRISMS

For Fly Ash Brick PRISMS, three specimens for 5, 6 and 7-Layered each were casted. Total 9 specimens were casted and tested under compression on the UTM. The dimensions of all Fly Ash Bricks PRISMS specimens is mentioned in Table-3. The casted PRISMS specimens are shown in Figure-5.

Table- 3: Details of Fly Ash Brick PRISMS

Sr No.	Details	Dimensions (mm) H × W × B	Label
1	5 Layered Fly Ash Brick Specimen-1	411.67 x 227.50 x 228.33	5FAP-1
2	5 Layered Fly Ash Brick Specimen-2	413.89 x 229.17 x 230.83	5FAP-2
3	5 Layered Fly Ash Brick Specimen-3	397.88 x 230.00 x 230.00	5FAP-3
4	6 Layered Fly Ash Brick Specimen-1	476.11 x 228.33 x 229.17	6FAP-1
5	6 Layered Fly Ash Brick Specimen-2	495.55 x 231.67 x 223.33	6FAP-2
6	6 Layered Fly Ash Brick Specimen-3	498.33 x 232.50 x 232.50	6FAP-3
7	7 Layered Fly Ash Brick Specimen-1	581.68 x 228.33 x 230.00	7FAP-1
8	7 Layered Fly Ash Brick Specimen-2	583.33 x 229.33 x 230.00	7FAP-2
9	7 Layered Fly Ash Brick Specimen-3	579.67 x 230.00 x 228.33	7FAP-3

Figure-5: Fly Ash Brick PRISMS Specimens

These specimens are loaded till the failure of the specimen when loaded in UTM of 1000 kN capacity. The stress strain curve for all specimens of Fly Ash Brick PRISMS is shown in Figure 06. The failure observed were spalling, corner crushing of the specimen and bond failure as shown in Figure-7.

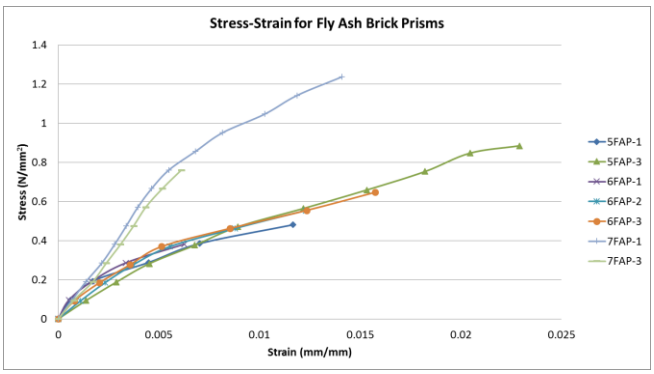

Figure-6: Stress Strain curve for Fly Ash Brick PRISMS

Splitting Failure of 5-LayerFly Ash Brick Prism

Bond Failure of 7-Layer Fly Ash Brick Prism

Spalling and corner crushing of Brick of 6-Layer Fly Ash Brick Prism

Figure-7: Failure of Fly Ash Brick PRISMS

6. RESULTS

All the specimens for 5,6 and 7-layered shows a non-linear stress strain relationship under the compression test. The breaking load was taken as the load at which the specimens fails under compression and does not have the capacity to take any further load. Height to thickness ratio is calculated so that correction factor can be applied as suggested in IS 1905-1987 [7]. After applying the correction factor, the basic compressive strength was determined and from the stress strain curve, the modulus of elasticity for the best fit curve was calculated. The values of the breaking load, basic compressive strength and modulus of elasticity is tabulated in Table-4 and Table-5 for Red Clay Bricks and Fly Ash Bricks PRISMS specimens. Results of some specimens for Red Clay and Fly Ash Brick PRISMS were neglected as the results were not in much line with the literature available.

Table-4: Basic Compressive Strength and Modulus of Elasticity for Red Clay Bricks PRISMS

Sr No.	No. of Brick Layer	Breaking Load (kN)	Height to thickness ratio (h/t)	Correction Factor	Basic Compressive Stress (N/mm²)	Avg. of Basic Compressive Stress (N/mm²)	Modulus of Elasticity (N/mm²)	Avg. Modulus of Elasticity (N/mm²)
1.	5	70	1.86	-	0.36	**0.39**	127.89	**121.25**
2.	5	85	1.88	-	0.42		114.56	
3.	6	110	2.29	0.7706	0.41	**0.38**	241.06	**258.16**
4.	6	95	2.16	0.7524	0.35		275.27	
5.	7	115	2.64	0.8168	0.45	**0.35**	273.50	**298.57**
6.	7	65	2.53	0.8036	0.25		323.64	

Table-5: Basic Compressive Strength and Modulus of Elasticity for Fly Ash Bricks PRISMS

Sr No.	No. of Brick Layer	Breaking Load (kN)	Height to thickness ratio (h/t)	Correction Factor	Basic Compressive Stress (N/mm²)	Avg. Basic Compressive Stress (N/mm²)	Modulus of Elasticity (N/mm²)	Avg. Modulus of Elasticity (N/mm²)
1.	5	25	1.809	-	0.120	0.189	38.47	45.79
2.	5	47	1.730	-	0.222		37.59	
3.	6	20	2.085	0.742	0.073	0.102	57.23	51.26
4.	6	30	2.139	0.749	0.104		43.98	
5.	6	35	2.143	0.750	0.121		52.58	
6.	7	65	2.547	0.8056	0.249	0.204	89.48	78.71
7.	7	40	2.520	0.8024	0.153		79.24	

7. CONCLUSIONS

- The test on individual units are very much in line with the literature. The water absorption of Fly Ash bricks is on higher side. This may be due to use of raw materials during manufacture process.
- The strength of mortar is more or less same as strength of bricks.
- Test on Red Clay Bricks PRISMS specimen shows that the average compressive stress is about 0.37 N/mm² while for Fly Ash Bricks PRISMS specimen the value is about 0.15 N/mm².
- For both the type of PRISMS specimens, the modulus of Elasticity increases as the number of bricks layer are increased.
- As compared with 5-Layered Fly Ash Bricks PRISMS, the Red Clay Bricks Specimens is having 2.06 times higher average compressive strength. For 6-layered and 7-layered Fly Ash Bricks PRISMS specimens, the Red Clay Bricks Specimens is having 3.72 and 1.72 times higher compressive strength respectively.
- Modulus of Elasticity of Red Clay Bricks PRISMS is 2.87, 5.03 and 3.79 times higher as compared with Fly Ash Bricks PRISMS for 5,6,7-Layered specimens respectively.

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